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Trace Metals in Liver from Bluefish, Tautog and Tilefish in Relation to Body Length

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Larger tilefish contained proportionately more Cd, Cu, and Fe in liver than smaller tilefish. Decreasing levels of Mn and Zn with body length were apparent only for females.

Livers from larger male bluefish were associated with higher concentrations of Fe than those from smaller males, while those from larger females contained lower concentrations of Cr than those from smaller females. The data suggest that future comparisons for trace metals which vary as a function of size be made only among fish of the same length.

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Introduction

Elements existing most probably as cationic species in seawater (Mn, Cu_2 Ni, Zn, etc.) and which tend to form strong ionic complexes tend to accumulate in the internal organs (Goldberg 1962). The occurrence of trace metals in liver has been well documented for bony fish. For example, Cr (Davis and Perkins 1958; Schiffman and Fromm 1959), Fe (Cowgill et al. 1968), Cu (Rose and Bodansky 1920), Zn (Polikarpov 1966) and Cd (Mount and Stephan 1967; Rowe and Massaro 1974) have all been reported to concentrate to various degrees in the liver. These and other metals, including Mn and Ni, have been detected in liver from the calico bass, *Paralabrax clathratus* (Stapleton 1968).

The relation between inferred age and metal content in teleosts has also received recent consideration. Eisler and LaRoche (1972) is studies with 6 length frequency size groupings of the mummichog, *Fundulus heteroclitus*, showed that graded increases in total body length were associated with progressive increases in whole body concentrations of Ca and Sr, and decreases in K, Mg, Na and Zn. Tong et al. (1974) found that as Cr increased, Mo and Sn decreased with age in eviscerated lake trout, *Salvelinus namaycush*, ranging from 1 to 12 years.

The purpose of the present study was to examine the relation between metal content in liver and body length (age) in male and female tautog, *Tautoga onitis*, tilefish, *Lopholatilus chamaeleonticeps*, and bluefish, *Pomatomus saltatrix*. This report provides the first known published account of such analysis for these three species of marine teleosts.

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Materials and Methods

Tautog and bluefish were collected between June and August 1971 by hook and line in the vicinity of Barnegat Light and adjacent New Jersey coastal waters. Tilefish were also taken by angling in the inshore waters of the Hudson Canyon between June and September. The range in total body length (mm) for each species was:

Species	Tautog	Tilefish	Bluefish
males	187–438 (17)	889–1092 (10)	546–889 (17)
females	219–419 (20)	635–889 (13)	406–991 (31)

The numbers in parentheses indicate the number of fish collected in each group. Shortly after capture, the whole liver was removed from each fish and wrapped in aluminum foil and frozen. Samples were prepared and analyzed for Cd, Cr, Cu, Fe, Mn, Ni, and Zn by atomic absorption spectrophotometry according to the methods of Eisler and LaRoche (1972).

Results and Discussion

Regardless of time of collection, all samples with the exception of tautog livers (with Cd concentrations below 7 mg/kg liver ash) contained measurable amounts of all seven elements. The absence of detectable cadmium in tautog liver is not understood. However, Eisler (unpublished) found older tautogs of 25 to 30 years to contain approximately 3x more cadmium in viscera per unit ash weight than younger tautogs. Since examination of calculated lengths (Cooper 1967) for this species would place individuals used in the present study between ages 2 and 11, it follows that degree of cadmium concentration in liver could likewise be age-dependent.

A correlation of 0.50 ($P < 0.05$) was demonstrated between increasing body length and wet weight/ash ratios for livers from female tautog. This suggests that levels of noncombustible minerals may decrease with age. No significant trends at the 0.05 level, however, were apparent for either tilefish or bluefish.

Significant differences for elements in liver showing no correlation with body length were found between male and female mean values for Fe in tautog ($t = 2.92$; $n = 37$); Ni in tilefish ($t = 2.64$; $n = 23$); and between male and female mean values for Cu ($t = 3.50$; $n = 48$), and Zn ($t = 4.75$; $n = 48$) in bluefish. No differences in mean values were detected at the 0.05 level between sexes for Mn and Zn in tautog, Cr in tilefish and Cd, Mn, and Ni in bluefish. The mean, standard deviation and range of all metal concentrations are shown in Table 1. The comparatively larger variations for iron in all three species agrees with findings by Underwood (1971), that individual variation in content of metals such as iron within animal species can be very high in the liver.

Metal concentrations showing significant trends with increasing body length are shown in Table 2. Graded increases in total body length of tilefish were associated with progressive increases in liver concentrations of Cd, Cu and Fe. Decreases in Mn and Zn were apparent only in females of this species. Liver ash from tautog contained decreasing levels of Ni with increasing size, while only livers from smaller males were associated with higher concentrations of Cr and Cu. Finally, livers from larger male bluefish contained proportionately more Fe while those from larger females contained less Cr.

Sexual differences of metal behavior in liver are difficult to interpret. Beck (1956) found female salmon

TABLE 1. Average concentrations of selected metals in teleost liver. All values are in milligrams element per kg ash.

Element		Mean	S.D.	Range
		Bluefish		
Cd[3]	male	30	30	10–150
	female	40	30	10–130
Cr	male	160	110	40–390
	female[2]	120	60	30–260
Cu	male	360	150	160–820
	female	680	360	150–1600
Fe	male[2]	28000	1700	3900–60000
	female	19000	8300	3900–40000
Mn[3]	male	160	30	110–220
	female	160	40	100–240
Ni[3]	male	100	80	30–330
	female	70	40	20–160
Zn	male	1700	570	1300–3600
	female	3700	1700	1100–7100
		Tautog		
Cd[1]	male	–	–	–
	female	–	–	–
Cr	male[2]	240	150	50–450
	female	200	120	20–420
Cu	male[2]	830	250	430–1350
	female	490	190	280–3700
Fe	male	14000	6500	5100–31000
	female	8500	4400	2500–19000
Mn[3]	male	160	50	100–300
	female	160	70	20–300
Ni	male[2]	260	150	70–460
	female[2]	200	130	30–470
Zn[3]	male	1500	290	800–1800
	female	1300	380	700–2300
		Tilefish		
Cd	male[2]	50	30	20–100
	female[2]	70	60	30–270
Cr[3]	male	20	10	10–40
	female	20	10	10–40
Cu	male[2]	210	90	80–320
	female[2]	340	140	140–590
Fe	male[2]	23000	9600	13000–38000
	female[2]	19000	5000	13000–25000
Mn	male	120	10	100–150
	female[2]	90	30	60–140
Ni	male	20	10	10–30
	female	30	10	20–40
Zn	male	1800	550	1100–2600
	female[2]	1800	480	1300–2800

[1] Not detectable.

[2] Indicates significant correlation with body length. See Table 2.

[3] Indicates no significant difference at 0.05 level between male and female mean values.

TABLE 2. Regression equations for effect of body length on selected elements in fish liver. Y = mg element/kg liver ash, X = total body length in mm, r = regression coefficient, P = probability level.

Element	Increase(i) or decrease(d) with body length	Sex	Regression equation	r	P
			Bluefish		
Cr	d	female	$Y = 210 - 0.10\ X$	−0.35	0.05
Fe	i	male	$Y = -51000 + 120\ X$	0.60	0.05
			Tautog		
Cr	d	male	$Y = 680 - 1.50\ X$	−0.74	0.01
Cu	d	male	$Y = 1300 - 1.20\ X$	−0.49	0.05
Ni	d	male	$Y = 710 - 1.50\ X$	−0.77	0.01
Ni	d	female	$Y = 660 - 1.60\ X$	−0.61	0.01
			Tilefish		
Cd	i	male	$Y = -300 + 0.40\ X$	0.81	0.01
Cd	i	female	$Y = -270 + 0.50\ X$	0.59	0.05
Cu	i	male	$Y = -580 + 0.80\ X$	0.65	0.05
Cu	i	female	$Y = -710 + 1.40\ X$	0.80	0.01
Fe	i	male	$Y = -74000 + 100\ X$	0.72	0.05
Fe	i	female	$Y = -14000 + 40\ X$	0.72	0.01
Mn	d	female	$Y = 300 - 0.30\ X$	0.83	0.01
Zn	d	female	$Y = 4400 - 3.30\ X$	0.59	0.05

Arripis trutta to contain higher values of Cu in liver than males and suggested this was due to differences in excretory mechanisms. Elemental composition has also been known to vary with gonad maturation. Eisler (1967) found that in sexually mature northern puffers, *Sphaeroides maculatus*, potassium concentrations in the ovary were measurably higher than in the testes.

Trends in elemental composition with age has primarily been concerned with studies on humans. For example, Bilek et al. (1959) established that absolute Mn content of liver increases until the fourth decade, at which point the concentration decreases. Limited studies on teleosts have attributed such trends to processes associated with growth and maturation. Cross et al. (1973) attribute decreasing levels of Fe in muscle of larger bluefish to possible compositional changes, decreased intake of metals in the diet of older fish, and dilution by growth. However, explanation of most elemental changes with age is hindered by lack of supporting data. Inter- and intraspecific elemental variations in teleosts are consequently difficult to interpret and have been suggested to vary with trophic level (Windom et al. 1973), metabolic activity (Sarata 1938), rate of growth (Palmer and Beasley 1967), excretory mechanisms (Beck 1956), source of collection (Alexander et al. 1973), and local sources of water pollution (Tong et al. 1972). Furthermore, the retention of metals such as copper in the liver may be complicated by corresponding levels of zinc and iron in the diet (Underwood 1971).

Conclusion

Since average levels of metal composition are often too variable to provide meaningful data, respective trends with body length or age may reveal a more valuable aspect of metal physiology. In the present study, liver concentrations of Cd, Cr, Cu, Fe, Mn, Ni, and Zn varied with body length among adults from three species of marine fish. If tissue metal analyses of teleosts provide an indication of aquatic pollution (Stapleton 1968) and response to toxic agents in the environment (Eisler 1972), this study suggests that comparisons for trace metals which vary as a function of body length should be made only among fish of the same age.

Literature Cited

Alexander, J. E., J. Foehrenbach, S. Fisher, and D. Sullivan. 1973. Mercury in striped bass and bluefish. *N.Y. Fish Game J.* 20:147–152.

Beck, A. B. 1956. The copper content of the liver and blood of some vertebrates. *Australian J. Zool.* 4:1–18.

Bilek, K., W. Mischel, K. Piskazeck, and K. Rothe. 1959. The manganese content of human liver in relation to age and sex. *Geront. Geriat.* 2:533.

Cooper, R. A. 1967. Age and growth of the tautog, *Tautoga onitis* (Linnaeus), from Rhode Island. *Trans. Am. Fish. Soc.* 96:134–142.

Cowgill, U. M., G. E. Hutchinson, and H. C. W. Skinner. 1968. The elementary composition of *Latimeria chalumnae*. *Proc. Nat. Acad. Sci.* 60:456–463.

Cross, F. A., L. H. Hardy, N. Y. Jones, and R. T. Barber. 1973. Relation between total body weight and concentrations of magnese, iron, copper, zinc and mercury in white muscle of bluefish (*Pomatomus saltatrix*) and a Bathy-demersal fish *Antimora rostrata*. *J. Fish. Res. Bd. Canada* 30:1287–1291.

Davis, J., and R. Perkins. 1958. Radioactive materials in aquatic and terrestrial organisms exposed to reactor effluent water. *Proc. 2nd Intern. Conf. Peaceful Uses Atomic Energy*. 18:423–428.

Eisler, R. 1967. Tissue changes in puffers exposed to methoxychlor and methyl parathion. *U.S. Bur. Sport Fish. Wildl. Tech. Pap. Ser.* No. 17:1–15.

———. Pesticide-induced stress profiles. *FAO Tech. Conf. Marine Pollution Eff. Liv. Res. Fish.*, Rome, 9–18 Dec. 1970.

———, and G. LaRoche. 1972. Elemental compo-

sition of the estuarine teleost, *Fundulus heteroclitus* (L.). *J. Exp. Mar. Biol. Ecol.* 9:29–42.

GOLDBERG, E. D. 1962. Elemental composition of some pelagic fishes. *Limnol. Oceanog.* 7 (suppl): LXXII-LXXV.

MOUNT, D. I., AND C. E. STEPHAN. 1967. A method for detecting cadmium poisoning in fish. *J. Wildl. Mgm.* 31:168–172.

PALMER, H., AND T. BEASLEY. 1967. Iron in the marine environment and in people who consume ocean fish, p. 259–262. *In* B. Arberg and F. Hungate (eds.) Radioecological Concentration Processes. Pergammon Press, London.

POLIKARPOV. G. 1966. Radioecology of Aquatic Organisms. North Holland Publ. Co., Amsterdam. 314 p.

ROSE, W. C., AND M. BODANSKY. 1920. Biochemical studies on marine organisms. *J. Biol. Chem.* 44: 99–112.

ROWE, D. W., AND E. J. MASSARO. 1974. Cadmium uptake and time-dependent alterations in tissue levels in the white catfish *Ictalurus catus*. *Bull. Environ. Contam. Toxicol.* 11:244–249.

SARATA, U. 1938. Studies on the biochemistry of copper. *Jap. J. Med. Sci.*, II. Biochem., 4:37.

SCHIFFMAN, R. H., AND P. O. FROMM. 1959. Chromium-induced changes in the blood of rainbow trout, *Salmo gairdnerii*. *Sewage Indust. Wastes* 31:205–211.

STAPLETON, R. P. 1968. Trace elements in tissues of the calico bass *Paralabrax clathratus*. *Bull. S. Calif. Acad. Sci.* 67:49–58.

TONG, S. C., W. H. GUTENMANN, D. J. LISK, G. E. BURDICK, AND E. J. HARRIS. 1972. Trace metals in New York State fish. *N.Y. Fish Game J.* 19:123–131.

———, W. D. YOUNGS, W. H. GUTENMANN, AND D. J. LISK. 1974. Trace metals in Lake Cayuga lake trout (*Salvelinus namaycush*) in relation to age. *J. Fish. Res. Bd. Canada* 31:238–239.

UNDERWOOD, E. J. 1971. *Trace Elements in Human and Animal Nutrition*. Academic Press, New York and London. 543 p.

WINDOM, H. R., R. STICKNEY, R. SMITH, D. WHITE, AND F. TAYLOR. 1973. Arsenic, cadmium, copper, mercury and zinc in some species of North Atlantic finfish. *J. Fish. Res. Bd. Canada* 30:275–279.

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